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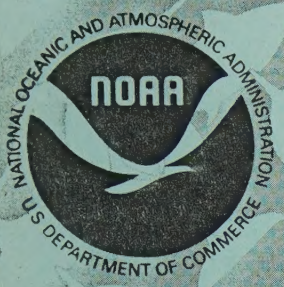

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RESULTS OF RESEARCH ON CALIFORNIA SEA LIONS, SAN NICOLAS ISLAND, 1983

CAROLYN B. HEATH AND JOHN M. FRANCIS

ADMINISTRATIVE REPORT LJ-84-41C

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SERVICE

RESULTS OF RESEARCH ON CALIFORNIA SEA LIONS, SAN NICOLAS ISLAND, 1983

Carolyn B. Heath and John M. Francis

University of California, Santa Cruz
Santa Cruz, California 95064

November 1984

This report was prepared by C. Heath and J. Francis under contract No. NOAA/81-ABC-00145 for the National Marine Fisheries Service, Southwest Fisheries Center, La Jolla, California. The statements, findings, conclusions and recommendations herein are those of the author(s) and do not necessarily reflect the views of the National Marine Fisheries Service. Dr. Douglas P. DeMaster of the Southwest Fisheries Center served as Chief Official Technical Representative for this contract.

Administrative Report No. LJ-84-41C

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RESULTS OF RESEARCH ON CALIFORNIA SEA LIONS, SAN NICOLAS ISLAND, 1983

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INTRODUCTION

In this report, we summarize the essence of our 1983 field research on the California sea lion population on San Nicolas Island. As this work is basically a continuation of our 1981 and 1982 research, we refer the reader to Heath and Francis (1983) for detailed information on methods, analysis and previous results. We present data on pup production, pup and juvenile mortality, population levels and female feeding cycles.

1983 was a strong El Niño year, affecting productivity throughout much of the eastern Pacific (Barber and Chavez, 1983). Reported effects include extremely high pup mortality among pinnipeds in the Galapagos and off Peru (Limberger et al. 1983), as well as altered fish species distribution and reduced breeding success of sea birds in California (Briggs et al 1984; Boekelheide et al 1984). Accordingly, we present many comparisons of the San Nicolas Island population between 1982 and 1983 in an effort to document responses of the sea lion to the El Niño event.

POPULATION DYNAMICS

San Nicolas Island, 1983

The California sea lion population on San Nicolas Island declined sharply in 1983 (Figure 1, Table 1). The peak subtotal count of 9,535 on June 20 was 30% lower than the comparable 1982 census. Although 1982 represented an increase over 1981, the 1983 population was still well below (18%) 1981 levels. Since we had a late season and fewer island censuses in 1981, many comparisons will be made here between 1983 and 1982 only. Comparisons between 1983 and 1981 show similar patterns, though of a somewhat lesser magnitude.

The most striking features of the 1983 population were the decreases in female and pup numbers. The June 19 peak of 6,128 females was 40% and 31% below the 1982 and 1981 peaks, respectively (Figure 2). Whereas they had comprised about 75% of the population in the two previous years, in 1983 females represented only 64% of the population.

Our peak pup count of 4,405 was taken on July 5, 1983. This figure is 37% lower than our peak 1982 count, and 43% lower than the peak pup count of 7,738 obtained by Stewart and Yochem (in press) in 1982. It is 34% below the comparable 1981 pup figures (Figure 3). The percentage decline of pups from 1982 and 1983 approximated that seen for females. Thus, while the reproductive rate for the population at large dropped in 1983, it remained similar for those animals actually on San Nicolas. Female/pup ratio calculations are easily altered by such factors as transient female groups, shifts in timings of peaks, etc. Nonetheless, these figures indicate that the reduction in the number of non-parturient females visiting the island was proportional to the reduction in parturient females.

Beginning in January 1983, aborted fetuses were found during all of our censuses. Seven were found in January, 1 in February, 52 in April, and 109 in mid-May. We do not have census data for the 1982 winter, however, our mid-May 1982 census found 31 fetuses as compared to the 109 in 1983. This suggests that premature pupping was high in the spring of 1983 and contributed to lower natality.

The maximum number of juveniles recorded during 1983 was 2,078 on May 15. The 1982 peak was May 16, with 1930 juveniles. Yearlings comprised the vast majority of both counts. Juvenile numbers dipped to a low of 1,101 on June 19, 1983, then stayed at around 1,200 for the remainder of the summer (Table 1). While the number of juveniles present mid-summer was roughly equal between 1982 and 1983, they represented an increased percentage of the population (16% in 1983, 11% in 1982) due to the decreased number of adult females present.

In contrast to the female and pup populations, the number of adult males remained very constant between the years (Figure 4). Their peak of 573 on July 5, 1983 is only 6% below the 1982 peak. Arrival and departure dates were also very similar for this class as a whole between 1982 and 1983 (Figure 4). This would indicate that adult males either respond to conditions

differently than adult females, or are exposed to different conditions affecting population distribution.

Unlike the adult males, subadult males have increased on San Nicolas Island since 1981 (Figure 4). Their numbers peak in late June, about two weeks before the adult male peak. The June counts for subadult males were 1,450, 1,608 and 1,763 for 1981, 1982 and 1983, respectively. Their percent composition of the population for the same years has been 13%, 12% and 19%. Again, their increased representation in 1983 is partially due to the decreased numbers of females.

Population trends at our two study sites in 1983 were similar to those found for the total island (Figures 5-7). Adult male numbers remained quite constant. The number of females dropped sharply in 1983. At area 232, 1981 female and pup levels were also well below those of 1982 but not as low as in 1983. Area 233 followed the island patterns more closely.

Given the effects that El Niño has had upon tropical pinnipeds and California fish and sea bird populations, it seems reasonable to assume that the decreased sea lion population on San Nicolas Island in 1983 is related to El Niño conditions as well. Increased premature pupping, pup mortality and female feeding cycle length (see appropriate sections) lend support to this idea.

When conditions return to normal, we would expect increased female numbers on the island again, however, we do not expect pup production to return to near 1981 or 1982 levels by 1984. This is because at our study sites the number of copulations decreased 50% from 1982 to 1983. Assuming a similar relationship between the number of copulations and the number of pups born from year to year we can anticipate a reduction in pup production. Therefore, unless a large number of copulations occurred away from the island, El Niño will have effects on pup production lasting longer than just the year of climatic anomaly.

FEMALE FEEDING CYCLES

Female feeding cycles were measured during 1983 by the same methods as outlined in Heath and Francis (1983). The analysis of those cycles is centered around "select" (highly visible) females, while also omitting trips to sea >19 days in length. These categories of females and trip lengths appear to be the most accurate and representative of feeding cycle patterns (see Heath and Francis 1983). The mean number of days on land for select females in 1983 was 1.8, nearly identical to the 1982 mean of 1.9 days (Table 2). At the same time, the mean length of trips to sea increased significantly. Omitting trips >19 days in length, the mean number of days at sea for 1983 (select females) was 4.7 as opposed to 3.2 in 1982, an increase of 47%. Omitting trips >10 days in length gives means of 3.6 and 3.0 days at sea for 1983 and 1982, an increase of 20% (t test, $p<.01$). The percentage of time that females spent at sea during the summer was therefore greater as well (see Table 2).

Due to the smaller female population in 1983 and correspondingly smaller sample sizes, it was difficult to make comparisons of feeding cycles between reproductive categories. At the least, however, there didn't appear to be any pronounced deviation from the 1982 pattern of females with pups having longer stays on land and shorter trips to sea than did other reproductive categories.

Scats were systematically collected throughout 1983 for prey species identification and are currently being analyzed by M. Lowry of the Southwest Fisheries Center. One unusually abundant potential prey species around San Nicolas Island in 1983 was the pelagic crab, Pleuroncodes. Huge swarms were prevalent in the warm waters associated with the El Niño conditions. Sea lions were observed eating them, and they have shown up in scats, but their proportion in the diet is not yet known. Altered distribution of other prey species is possible given the oceanic anomaly. Besides the expected change in prey composition which this might cause, this altered distribution might explain the changes in female feeding cycle patterns seen in 1983.

PUP MORTALITY

The following section can be best understood through comparison with our previous work on pup mortality (Heath and Francis 1983). In our 1983 report, we demonstrated that dead pup counts conducted periodically or once a season grossly underestimated actual pup mortality due to loss of carcasses and scanning error. We measured daily pup mortality at two study areas, generated estimates of associated errors, and applied them to larger scale counts to achieve a good estimate of total island pup mortality. In addition, we tested a pup mortality estimation technique used by Bonnell et al (1980) and found it to be of uncertain value as a managment tool.

During the 1983 breeding season, we repeated our measurements in order to assess changes in pup mortality and to determine whether or not correction factors such as carcass loss and scanning error were consistent from year to year. By demonstrating that the errors associated with dead pup counts were invariable, the validity of such counts as estimators of pup mortality could be assured. We also tested the Bonnell et al estimation procedure to better determine its usefulness.

A comparison between the 1982 and 1983 breeding season mortality values, shown in Table 3 reveals changes in both pup mortality and the correction factors. Pup mortality increased at both study areas with 73 (17%) and 59 (12%) of the pups dying at areas 232 and 233 respectively (see Heath and Francis 1983 for methodology). In addition, our total island dead pup count of 250 when adjusted for 39% carcass loss (Table 4) and 59% scanning error (Table 5) represented 18% of the pup production for 1983. This also indicates an increase over the 1982 levels.

The winter storms of 1982-3 produced gross changes in beach topography on San Nicolas Island, which unlike the preceding two years, persisted through the breeding season. This resulted in a greater amount of exposed rock on beach areas that were previously covered with sand. Pup carcasses are better retained and less visible among boulders than on flat sand, thus explaining

the changes in both decreased carcass loss and increased scanning error observed. The retention of carcasses also explains the lower error associated with the end of the season count in 1983 as compared to that in 1982 (Tables 1 and 4).

Measurements of daily mortality rate are critical to the Bonnell et al mortality estimation procedure and are presented in Table 7 and plotted in Figure 8. In order for the estimation procedure to work, the daily mortality rate must be predictable from year to year for a one to two week sample period. Dead pup counts in conjunction with the known daily mortality rate can then be used to calculate total breeding season mortality from a relatively small sample. Our 1983 results for San Nicolas Island show daily mortality rate curves much different from the 1982 SNI curves and the 1976-77 Santa Barbara Island curve (see Figure 9 for reference). It appears that the daily mortality rate patterns are variable from year to year making the Bonnell et al mortality estimation procedure difficult to apply at this time.

This past year of research on pup mortality has shown that conditions such as beach topography can change so that periodic dead pup counts may not consistently represent pup mortality from year to year. Future investigations will reveal whether or not the changes observed in 1983 were anomalous. In fact, environmental conditions affecting carcass loss and scanning error could typically be constant from year to year.

It should also be noted that since carcass loss decreased and scanning error increased from 1982 to 1983, this introduces the possibility of offsetting effects. Table 8 shows the combined effects of the two factors indicating that when mean values are applied (method C), there is little change in the total correction factor between years. There is difficulty in utilizing these correction factors given that they are variable between study sites and based on relatively small samples. In our 1983 report and this report, we have decided to use the area 233 scanning error value due to greater observer familiarity with area 232. This type of bias remains untested, and it may be more accurate to use a mean value for scanning error instead (method B). Table 8 shows that the effect of using the mean value is a reduction in the estimated total island mortality to 14% and also a reduction in the 1983 total correction factor. Continued research at our study areas, now that the topography has returned to normal, will help to refine our estimations of carcass loss and scanning error.

As in our last year's work on pup mortality we have arrived at measurements at our study sites that agree with total island estimates. It is evident that mortality was higher in 1983, increasing from 10 to 14% or from 11 to 18% depending upon which scanning error factor is utilized. This increase in mortality coincided with a 60% decline in pup production for San Nicolas Island as well as a significant decrease in pup weight at tagging (Table 9) and is probably associated with the extensive biological effects of the 1982-3 El Niño (Barber and Chavez 1983, Briggs et al 1984).

FIRST YEAR MORTALITY

In our 1983 report, we concluded that tag resights of one year old sea lions gave exceptionally low and probably erroneous survival estimates, presumably due to the numbers of animals of that age class remaining at sea. Whether or not the survival estimates are accurate can be demonstrated through continued resight efforts that monitor interisland movements and the eventual return of tagged individuals to the rookeries. We continued our program of tagging and resighting using the methodology outlined in Heath and Francis (1983). The following is a brief summary of our resights during the 1983 breeding season (May 14 through August 14). A tagging summary is provided in Appendix B.

We were able to search for tagged individuals of two cohorts during the 1983 season, those tagged as pups in 1981 and those tagged in 1982. From the 1981 year class, only two tagged individuals were sighted on San Nicolas Island out of 188 originally tagged. During the same period, at least 13 others from the same cohort were sighted at other islands including four on Año Nuevo Island and 9 on the Farallones (L. Higgins and H. Huber, pers. comm.). Apparently at age two, a large portion of the sea lions are spending time away from the island of birth. The fraction of the cohort that is alive at age two remains to be determined.

The 1982 year class showed stronger representation on SNI of one year of age than did the 1981 year class at the same age. In 1982 20/188 or 11% of the 1981 year class was sighted during the breeding season as compared to the 1983 sighting of 52/288 or 18% of the 1982 year class. Either the latter showed greater survival or greater land use during 1983. The resighting effort was equal for both years.

CONCLUSION

Comparisons of our 1983 data with that collected during 1981 and 1982 reveal that dramatic changes in the sea lion population of San Nicolas Island occurred during the strong El Niño event. These changes included large reductions in the female population. Pup production, and pup weights, in addition to increases in pup mortality and in the amount of time spent at sea by females. Similar reductions in the breeding success of most seabirds in California as well as reports of altered fish species distributions substantiate the idea that the 1983 changes in the sea lion population were a response to large scale environmental changes resulting from the El Niño event. Future studies will determine the persistance of this climatic change and the extent of its biological consequences.

ACKNOWLEDGEMENTS

We thank Cdr. E. Giffin and Mr. Ron Dow for their continued support of our research on San Nicolas Island. Chip Deutch and Mark Lowry for their field assistance and the 1983 tagging crew for their hard work and good company. This research was conducted under U.S. Government contract #81-ABC-00145 through the Southwest Fisheries Center, Coastal Marine Mammals Program, directed by D. DeMaster. Additional support was provided by the Biology Board, University of California at Santa Cruz.

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Table 1. Total island census summary for San Nicolas Island, 1983.

Date	Male	SAM	Female	Juvenile	Subtotal	Pup	Total
1/30/83	0	297	3481	148	3926	6236	10162
2/27	0	491	2959	141	3591	5665	9256
4/16	6	485	1770	88	2349	3116	5465
5/15	6	484	3787	2078	4457	2	6355
5/29	30	570	4626	1692	6918	127	7045
6/ 5	112	673	4030	1447	6262	728	6990
6/19	543	1763	6128	1101	9535	3281	12816
7/ 5	573	1575	4411	1201	7760	4405	12165
7/17	511	1009	5020	1204	7744	4005	11749
8/ 3	100	156	4171	1218	5645	4214	9859
8/13	8	98	3290	1209	4605	3498	8103

Table 2. Mean days on land for females on San Nicolas Island, 1982 and 1983 (select category females only).

			Area 232	Area 233	232 & 233 combined	Total % time spent at sea
$\bar{x}$ DAYS ON LAND:						
a)	all visits	1982	1.8	2.1	1.9	
		1983	1.9	1.8	1.8	
$\bar{x}$ DAYS AT SEA:						
a)	omitting trips >19 days in length	1982	3.0	3.5	3.2	62.7
		1983	4.9	4.6	4.7	72.3
b)	omitting trips >10 days in length	1982	2.9	3.1	3.0[1]	61.2
		1983	3.5	3.7	3.6[1]	66.7

[1]Significant difference, $p<.01$

Table 3. Comparison of pup mortality estimates and sources of error for San Nicolas Island, 1982 and 1983.

	1982		1983	
		% Mortality		
Pup mortality				
Area 232	12		17	
Area 233	10		12	
Total island	11		18	
		% underestimation resulting from each factor		
Carcass loss				
Area 232	46		38	
		$\bar{x}$=55		$\bar{x}$=39
Area 233	64		40	
Scanning error				
Area 232	7		25	
		$\bar{x}$=14		$\bar{x}$=42
Area 233	21		59	
Beach walk error				
Area 232	54		34	
		$\bar{x}$=66		$\bar{x}$=45
Area 233	78		56	

Table 4. Carcass loss estimates for biweekly censuses on areas 232 and 233, San Nicolas Island, 1983.

Census date	Proportion of new dead pups lost between censuses[1]		
	Area 232	Area 233	Combined
5/29	6/11	1/3	7/14=50%
6/5	2/6	0/3	2/9=22%
6/19	4/10	6/11	10/21=48%
7/5	3/17	6/15	9/32=28%
7/17	9/20	6/16	15/36=42%
	24/64=38%	19/48=40%	43/112=38%

[1]Calculated as (lost/total new dead)

Table 5. Scanning error estimates for biweekly censuses on areas 232 and 233, San Nicolas Island, 1983.

Census date	Proportion of dead pups present that were overlooked at the time of the census		
	Area 232	Area 233	Combined
5/29	1/5	1/2	2/7=29%
6/5	1/4	2/3	3/7=43%
6/19	0/6	2/5	2/11=18%
7/5	3/14	6/9	9/23=39%
7/17	5/11	6/10	11/21=52%
	10/40=25%	17/29=59%	27/69=39%

Table 6. Accuracy of beach walk dead pup counts on areas 232 and 233, San Nicolas Island, 1983.

Date	Area	Dead pups distinguishable from blind	Dead pups counted on beach	Total known to have died on beach
8/6	232	10(13%)[1]	52(66%)	79
8/7	233	9(14%)	29(44%)	66

[1]Percent of total known to have died

Table 7. Daily percent of total mortality calculated from biweekly total island censuses, San Nicolas Island 1983.

Census date	New dead pups	Days since last census	Percent of total mortality	Daily percent of total mortality
5/29	45	14	45/238 = 18.9%	1.4
6/5	27	7	27/238 = 11.3%	1.6
6/19	49	14	49/238 = 20.6%	1.5
7/5	64	16	64/238 = 26.9%	1.7
7/17	53	12	53/238 = 22.3%	1.9
	238		100.0%	

Table 8. Total island pup mortality estimates for San Nicolas Island, 1982 and 1983.

Estimation method[1]	1982			Mortality	1983			Mortality
A without correction factors	334	[7738 +	334] =	.045	250	[4405 +	250] =	.054
B with $\bar{x}$ C.L. and 233 S.E.	$\frac{334}{(.45)(.79)}$	7738 +	$\frac{334}{(.45)(.79)}$ =	.108	$\frac{250}{(.62)(.41)}$	4405 +	$\frac{250}{(.62)(.41)}$ =	.183
C with $\bar{x}$ C.L. and $\bar{x}$ S.E.	$\frac{334}{(.45)(.86)}$	7738 +	$\frac{334}{(.45)(.86)}$ =	.100	$\frac{250}{(.62)(.58)}$	4405 +	$\frac{250}{(.62)(.58)}$ =	.136

	Combined correction factors: [(C.L.) (S.E.)]	
B	(.45) (.79) = .356	(.62) (.41) = .254
C	(.45) (.86) = .387	(.62) (.58) = .360

1.C.L.=(1-carcass loss) and S.E.=(1-scanning error) used in denominator to estimate actual number of pups that died. See Table 3 for original values.

Table 9. Mean weight of pups at tagging,[1] San Nicolas Island, 1982 and 1983.

	MALE			FEMALE		
	$\bar{x}$ (lbs)	S.D.	N	$\bar{x}$ (lbs)	S.D.	N
1982	34.8[2]	6.4	153	29.8[3]	5.3	135
1983	28.4[2]	6.6	110	24.5[3]	4.9	123

[1]Pups tagged on August 7-8, 1982 and on August 6-7, 1983

[2]Significantly different, t test, $p<0.01$.

[3]Significantly different, t test, $p<0.01$.

Figure 1. Peak numbers of sea lions on San Nicolas Island, June 1981-1983.

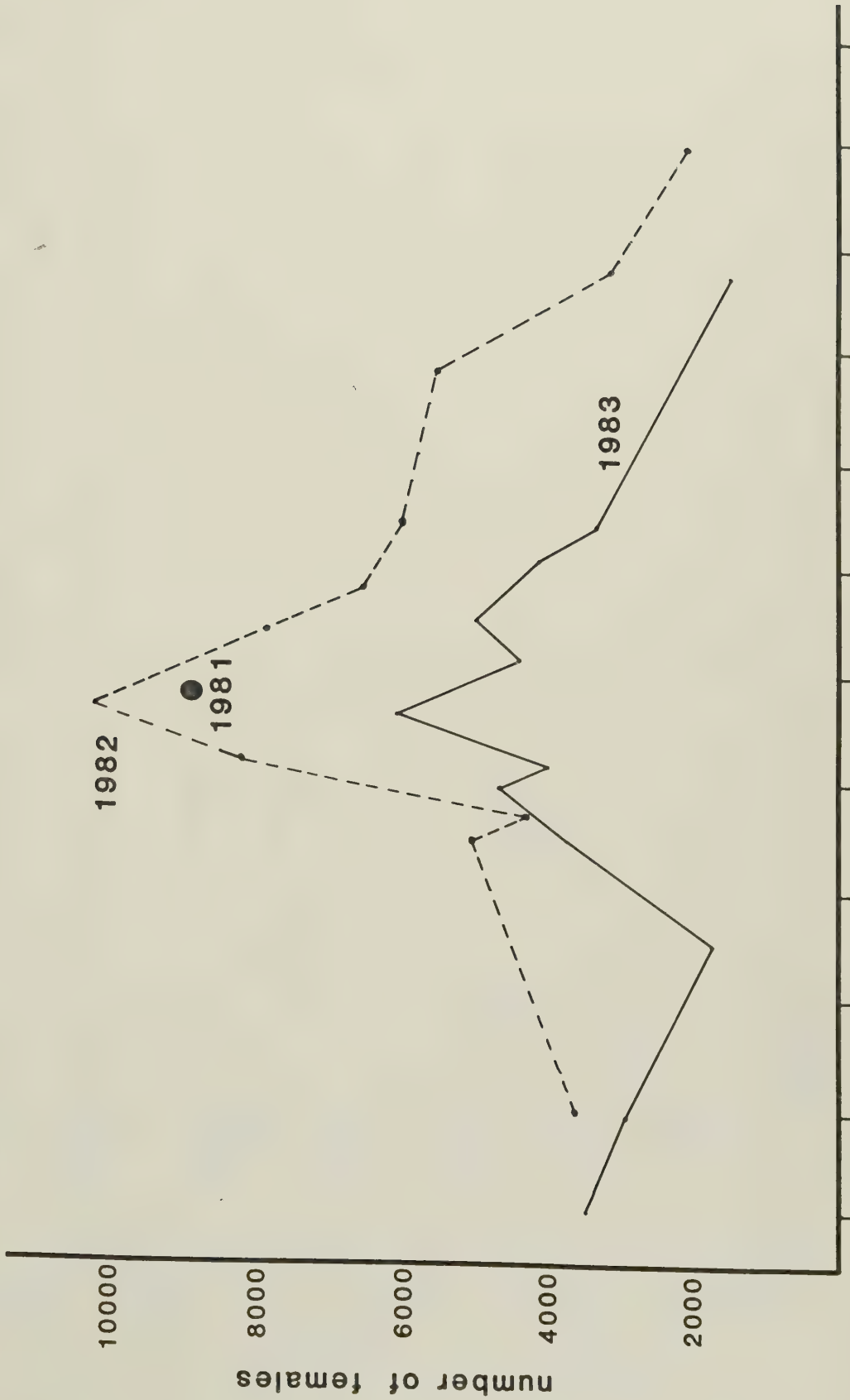
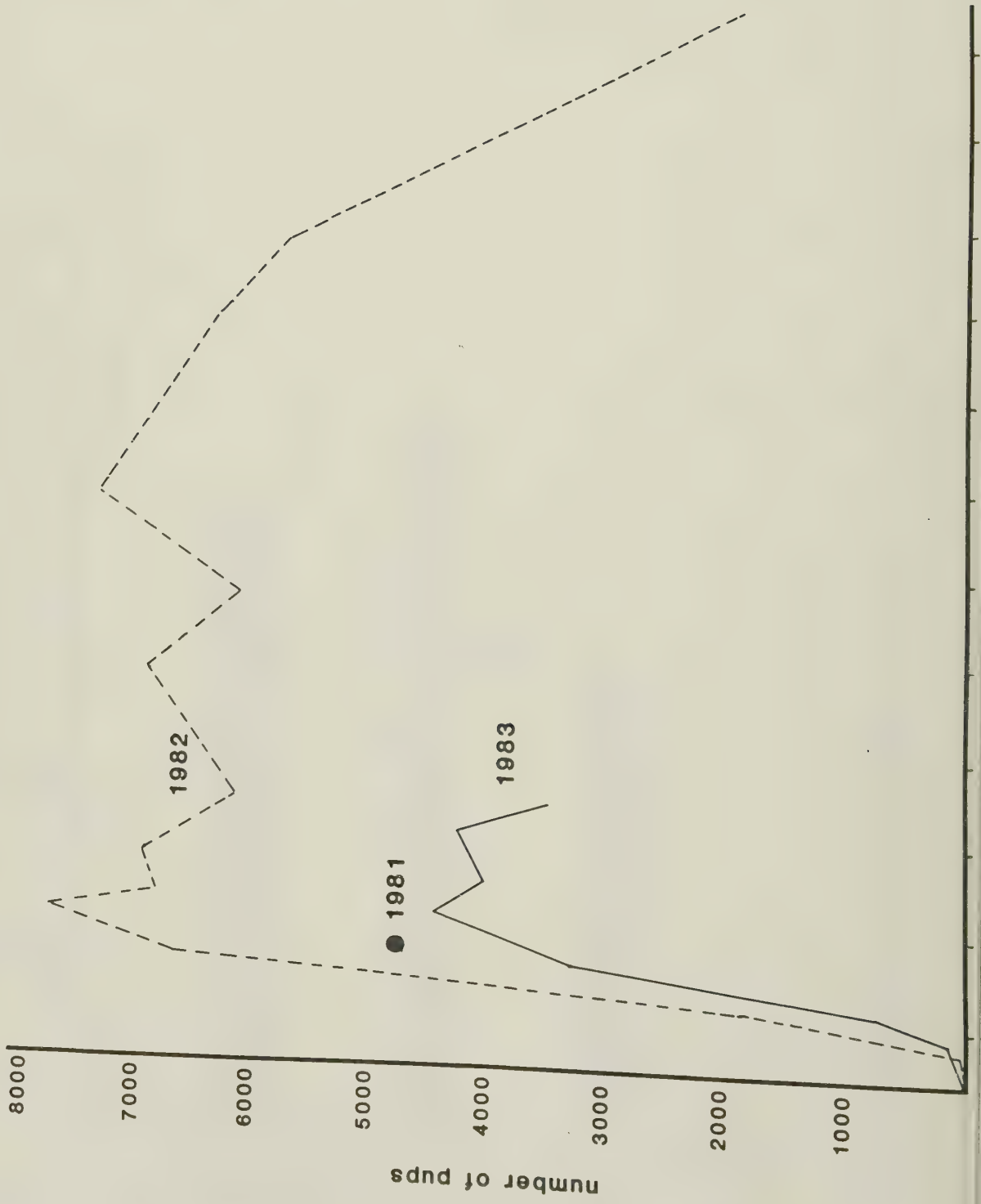


Figure 2. Number of females on San Nicolas Island, 1981-1983.

Number of pups on San Nicolas Island, 1981-1983



Number of males and SAMs on San Nicolas Island, 1981-1983

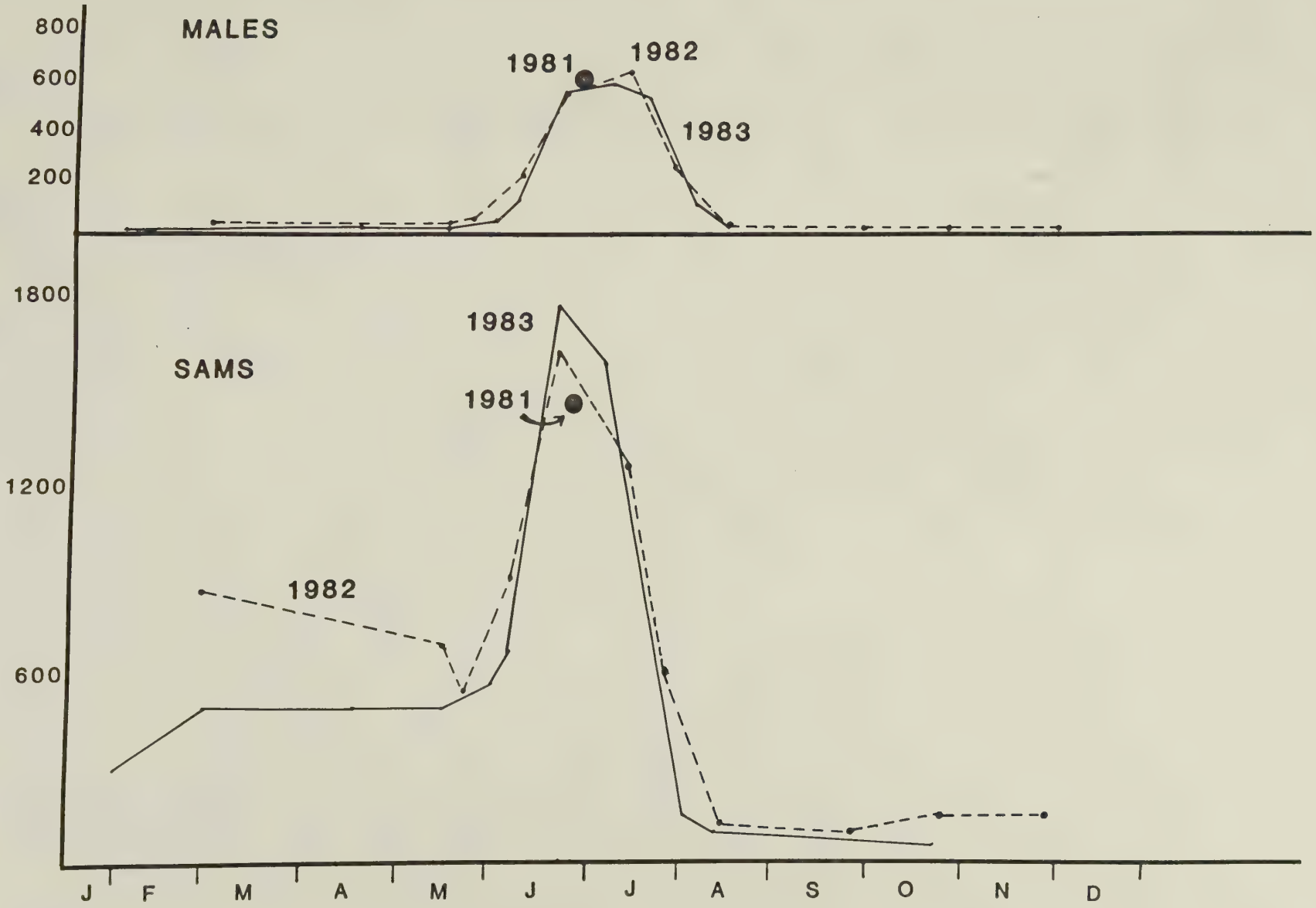


Figure 4. Number of males and SAMS on San Nicolas Island, 1981-1983.

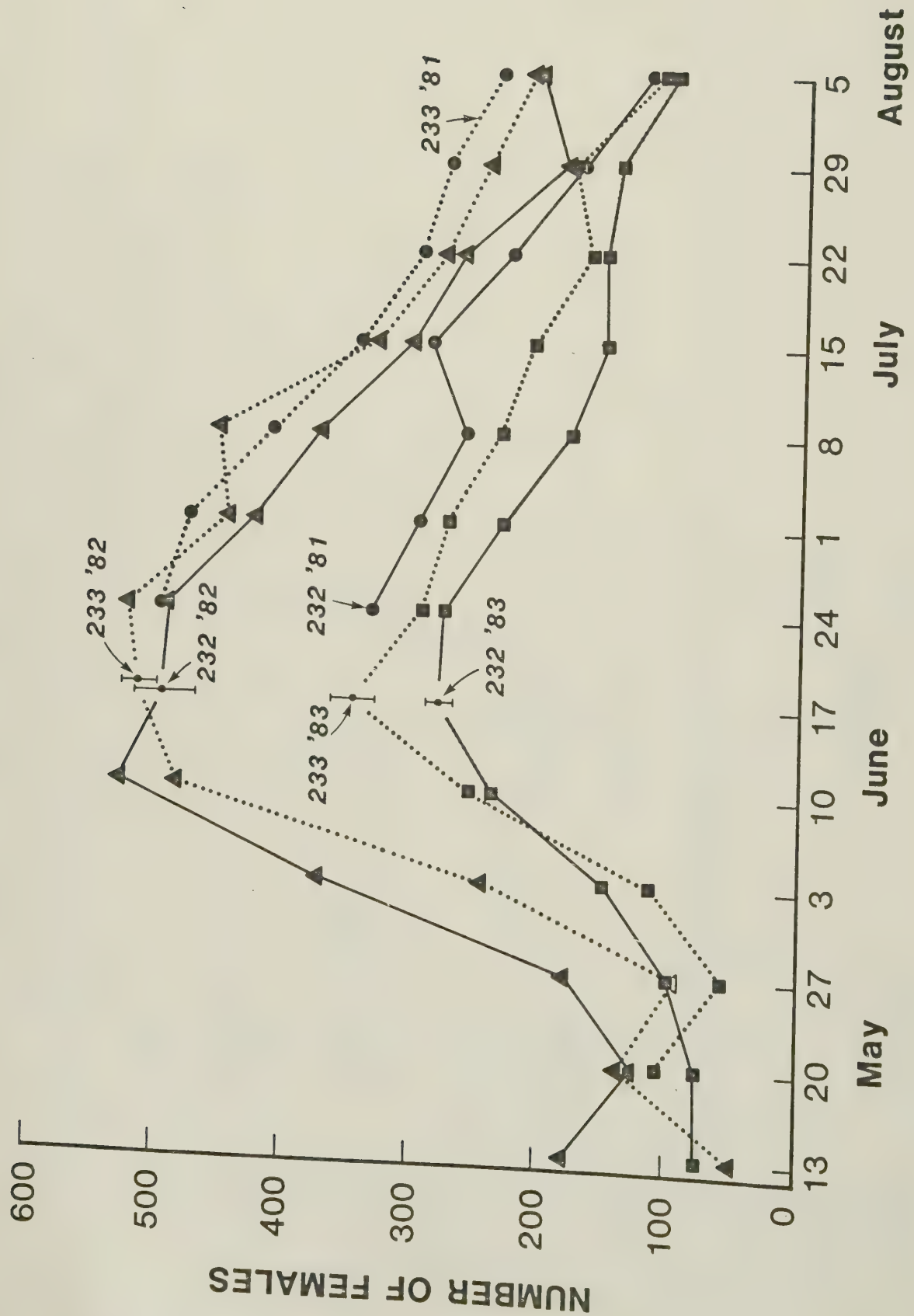


Figure 5. Number of females at areas 232 and 233, San Nicolas Island, 1981-1983. Points represent weekly means, error bars equal to 1l standard deviation (presented for 1982 and 1983 data only).

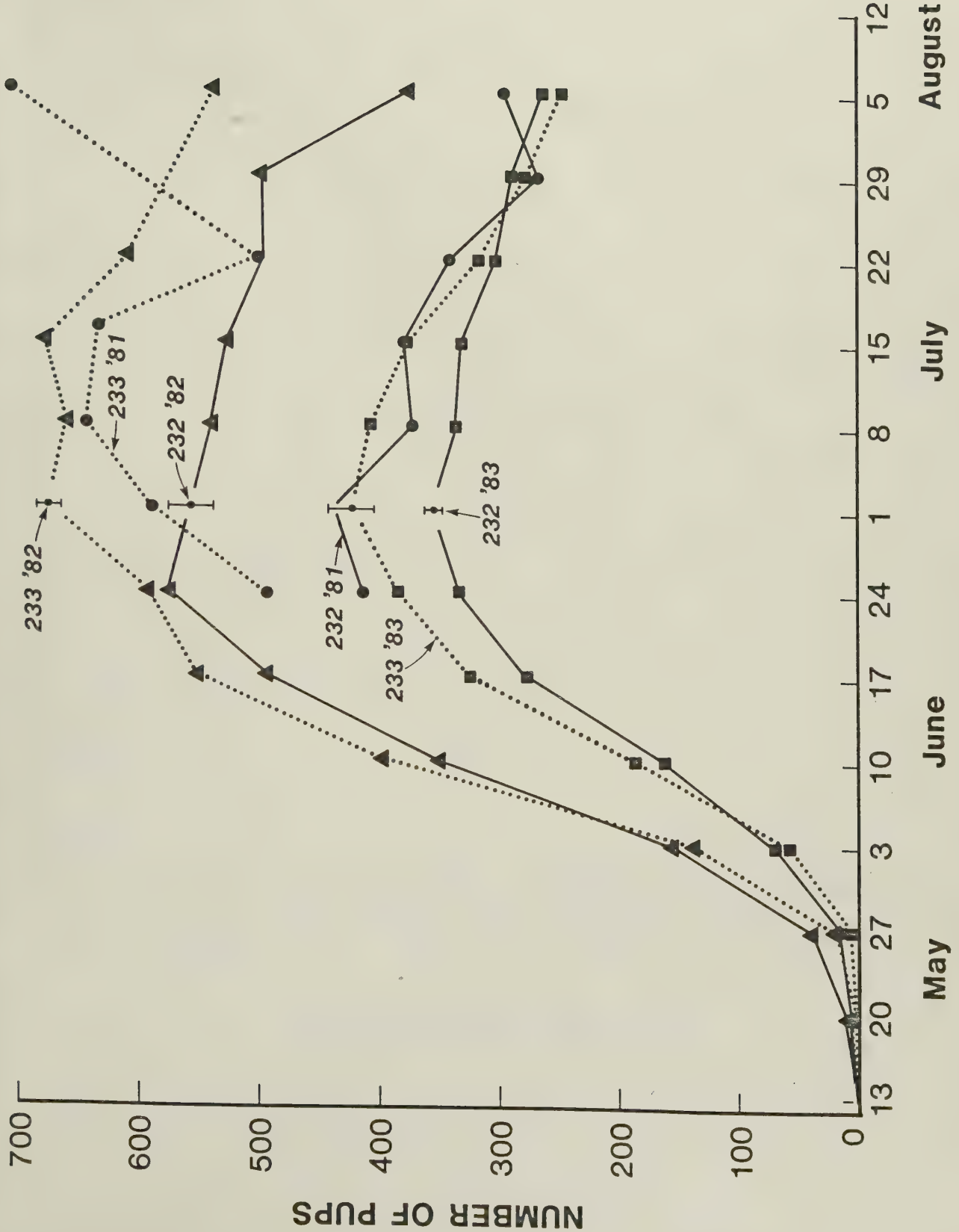
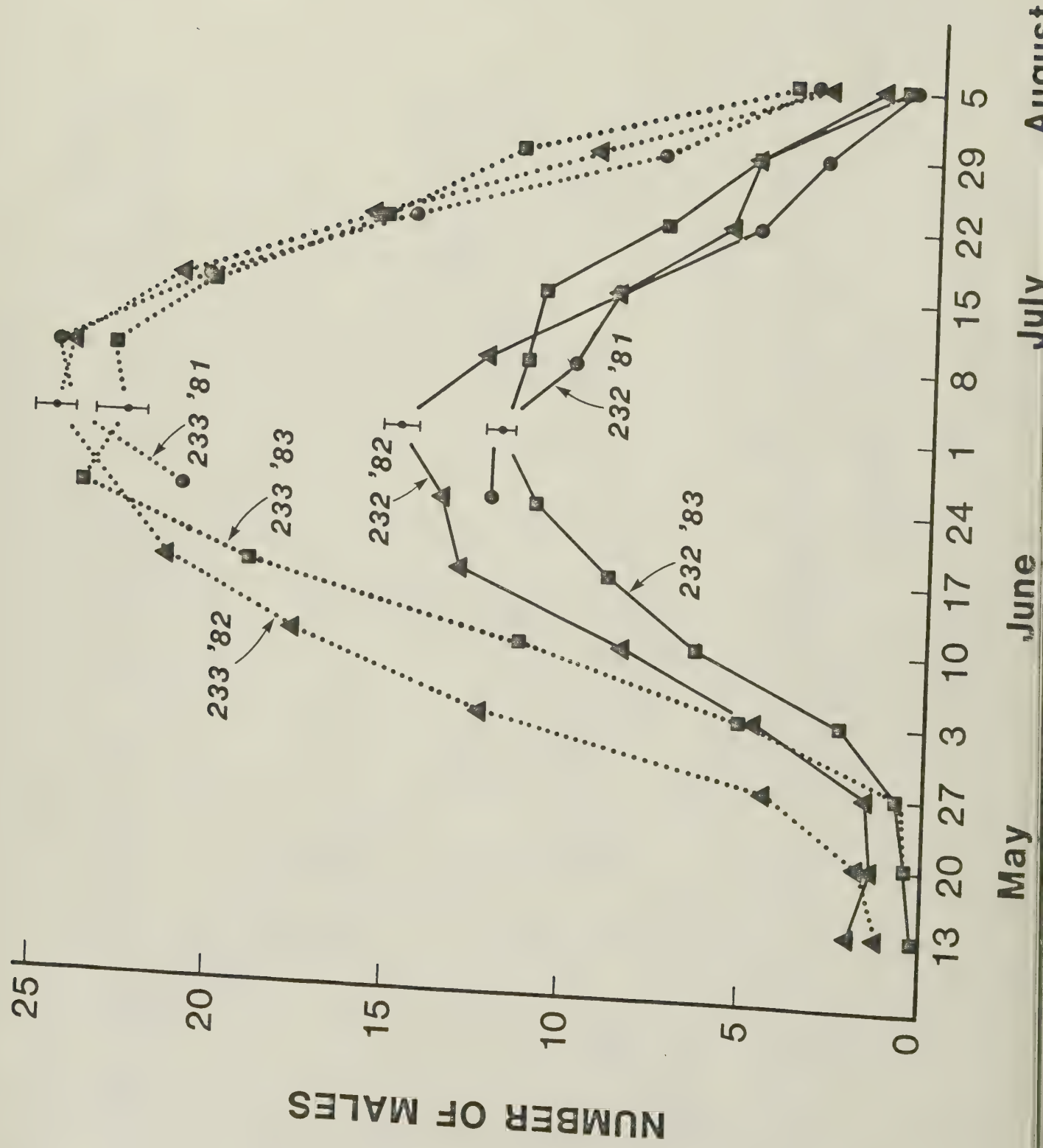


Figure 6. Number of pups at areas 232 and 233, San Nicolas Island, 1981-83.


NUMBER OF MALES
25
20
15
10
5
0
13 20 27 3 10 17 24 1 8 15 22 29 5
May
June
July
August
233 '81
233 '83
233 '82
232 '82
232 '81
232 '83

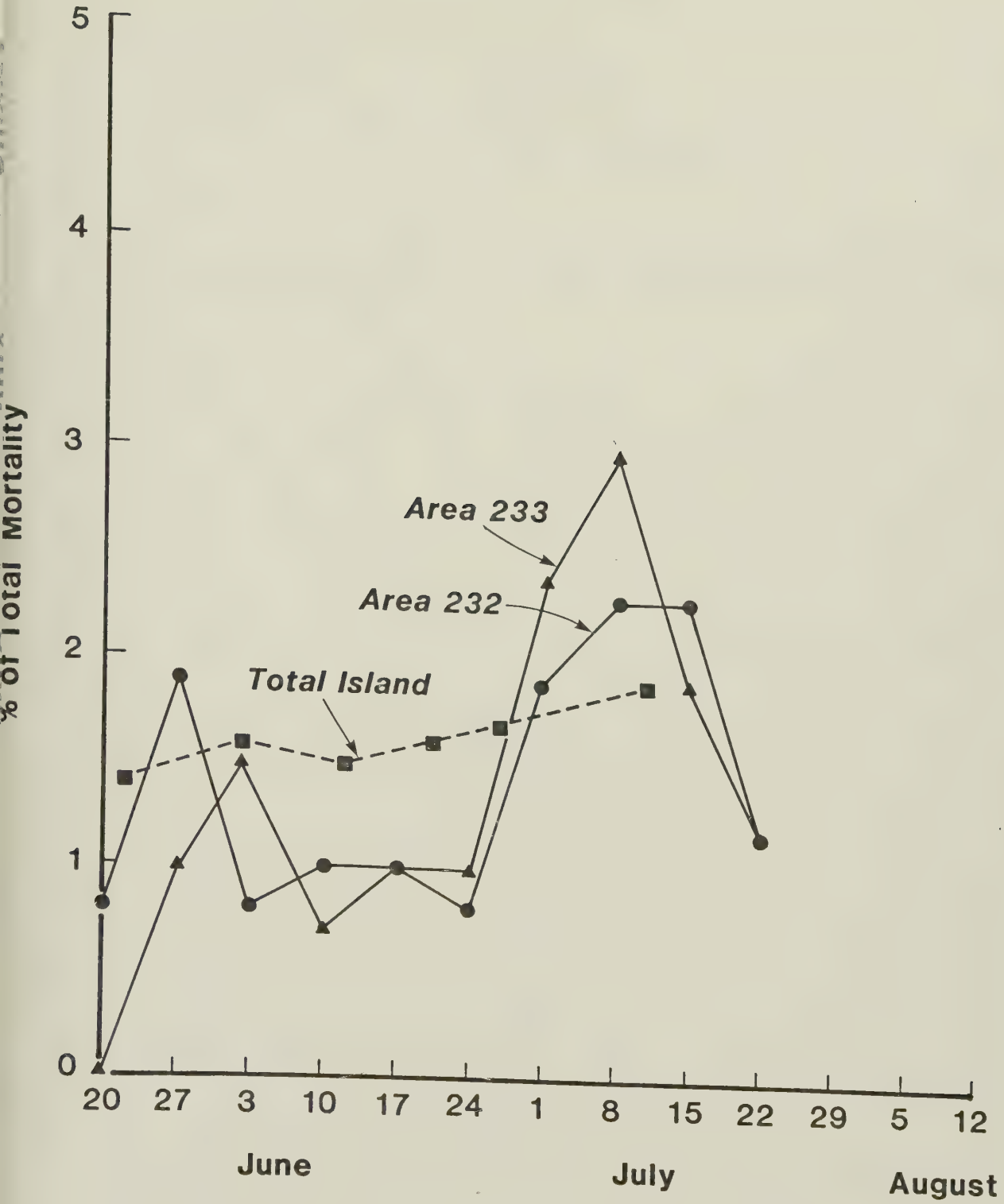


Figure 8. Percent of total pup mortality for San Nicolas areas 232, 233 and total island, 1983.

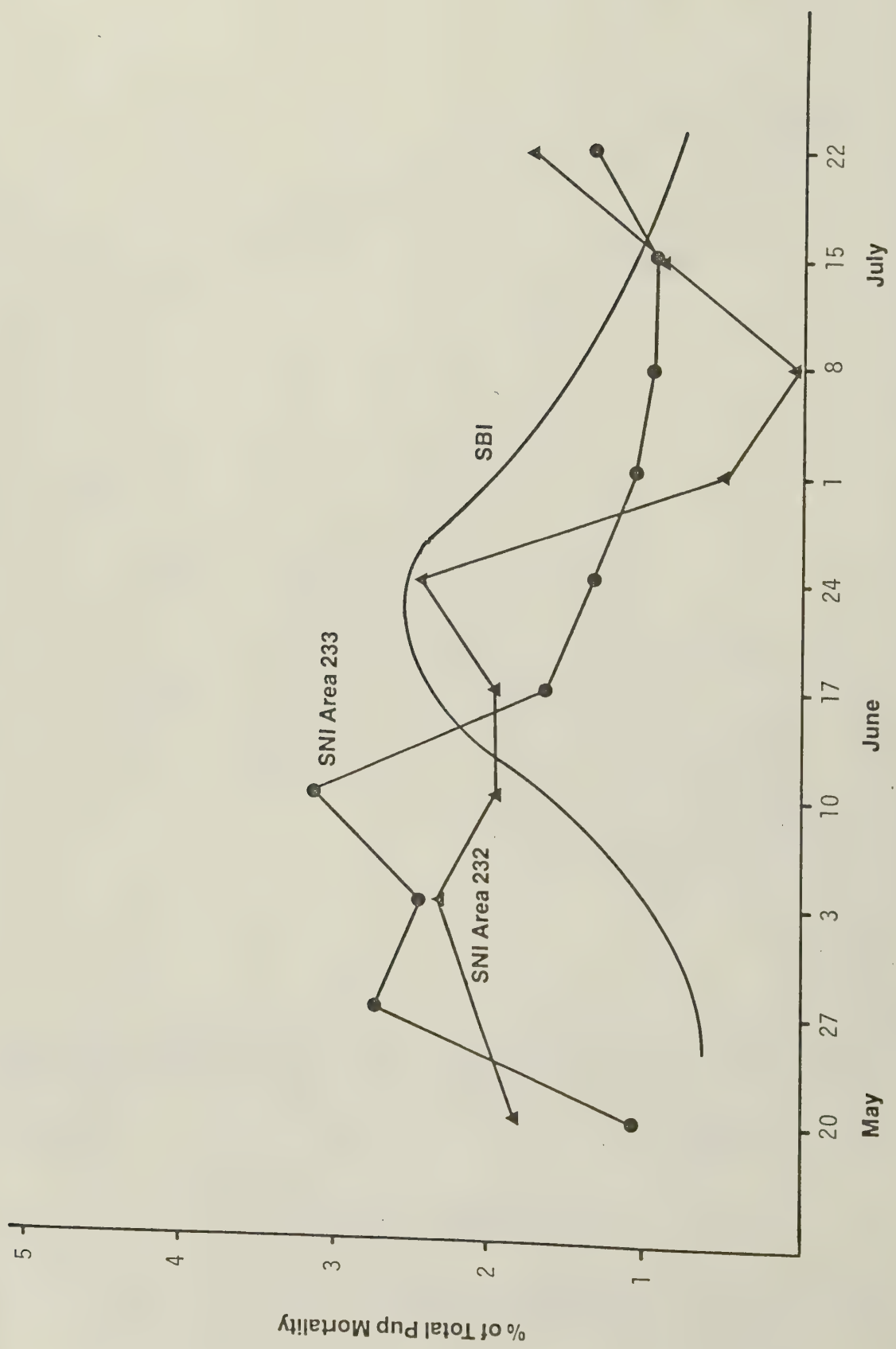


Figure 9 Percent of total pup mortality for San Nicolas Island areas 232 and 233, 1982, calculated by weekly means. Santa Barbara Island curve 1976-77 included for comparison.

APPENDIX A

Summary of Field Research Activities
San Nicolas Island 1983

1. 13 May-15 August 1983. Performed studies of California sea lions on San Nicolas Island, CA. All work performed from observation blinds except as noted below.

2. Island censuses and tag resights on:

30 January	19 June
27 February	5 July
16 April	17 July
15 May	3 August
29 May	13 August
5 June	

3. Captures for application of radio and sonic tags and radioisotopic tracers:

26 June BLM area 212 - capture
28 June BLM area 233 - capture
1 July BLM area 233 (2 females) -captures
15 July BLM area 233 - recapture

4. Attempted at sea tracking of sonic tagged females:

26 July - 7 July

5. Pup tagging:

6-7 August, Details in Appendix B

APPENDIX B

Tags applied to California sea lions
San Nicolas Island 1983

Date	Location	Tags Applied[1]	Number of Animals Tagged
8/6/83	232	601-647 649-653 655-667 669-675 677-678 680-684 686-690 692-694 696-700 704 706-728	116 pups
		701-703 705	4 adult females
8/7/83	233	729-787 789-799 801-848	118 pups
			234 pups 4 adult females

[1]All animals double tagged, red Riese tags, matching numbers.